commercial market application in developing helicopter procedures for offshore oil platforms and inner city skyscrapers where turbulence is a major problem.

Point of Contact: D. Giovannetti
(650) 604-3871
dgiovannet@mail.arc.nasa.gov

Intelligent Neural Flight and Propulsion Control System

John Kaneshige, Karen Gundy-Burlet

The NeuroEngineering Laboratory at Ames Research Center develops flight control software that utilizes neural networks to compensate for failures resulting from control surface damage or system malfunctions. A neural network is software that works through pattern recognition, and thus is able to "learn" from sensory input, resulting in systems that can adapt to changes in their external circumstances. Neural networks have been the subject of theoretical and applied research since the early 1960s. They have been applied to a wide range of problems: from investment analysis to the control of modem equipment.

Modern commercial aircraft are among the safest transportation systems ever designed. But even with their track record of successful operation, aircraft remain vulnerable to failures of flight-control systems, whether because of accidents or equipment malfunctions. Post-accident analyses of catastrophic flight-control accidents show that stricken aircraft usually retain some working control surfaces at the time of the crash. Given enough time, a skilled pilot can determine how to compensate for the loss of a control surface, but there is usually not enough time during such an emergency for a pilot to determine the nature of the failure and learn how to compensate for it.

In 1983 a mid-air collision in the Sinai resulted in the loss of nearly all of one wing from an F-15. Even under these dire circumstances, the pilot actually managed to land the disabled aircraft successfully, demonstrating that control of such badly damaged aircraft is possible. Is it possible to develop software that is capable of relearning the flight behavior of a damaged aircraft? Can the resulting "knowledgeable system" adapt the control of the aircraft in a way that effectively compensates for changing aircraft behavior that arises as a result of serious damage? A first-generation neural flight-control system is currently being tested on a modified F-15 aircraft at NASA's Dryden Flight Research Center to answer these questions (fig. 1).

Commercial aircraft pose a different challenge than do military aircraft, a result of their inherently more stable designs and the

Fig. 1. F-15 ACTIVE Aircraft.

relatively benign environments in which they operate. Commercial transports are also less maneuverable, however, which means that when severe damage occurs the results can be catastrophic. An analysis of recent transport aircraft accidents shows that in many cases, engines are still operational at the time of the crash. So with this in mind, a second-generation neural flight-control system was developed and integrated with another piece of NASA software, Propulsion Controlled Aircraft (PCA). PCA manipulates engine throttles, thereby enabling the aircraft to be maneuvered and flown without the use of the control surfaces in a limited flight envelope.

The combined Intelligent Neural Flight and Propulsion Control System (INFPCS) utilizes engine control with whatever remaining control surfaces are operational. INFPCS was successfully demonstrated in the Advanced Concepts Flight Simulator at Ames over a period of 5 weeks in FY00 (fig. 2). This achievement paved the way for this technology to advance to a flight-test phase.

In addition to enhancing aircraft safety, neural flight control offers benefits during software design and development. Neural networks can enable the development of flight controllers for new aircraft in significantly less time than it currently takes, thereby saving enormous expense during the design and development process.

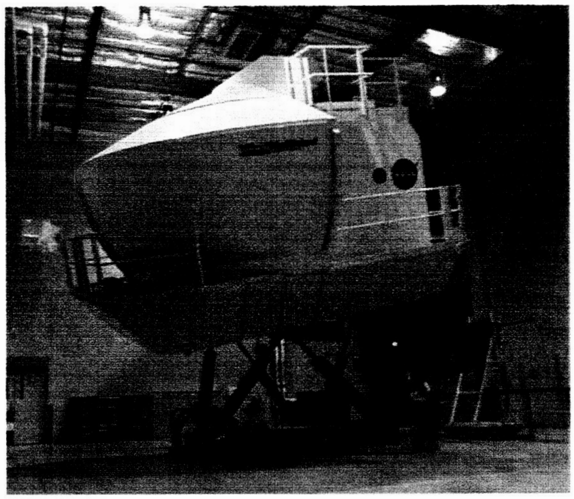

Fig. 2. The Advanced Concepts Flight Simulator at Ames Research Center.

Point of Contact: Guy Power
(650) 604-5989
gpower@mail.arc.nasa.gov

Large Rotor Research Program

Thomas R. Norman, Patrick M. Shinoda, Stephen A. Jacklin

A significant operational milestone for NASA's Rotorcraft Program was met in FY00 with the installation and initial testing of a UH-60 Blackhawk rotor on the Large Rotor Test Apparatus (LRTA) in the 80- by 120-Foot Wind Tunnel at Ames Research Center. This installation (see fig. 1) is the culmination of a development program undertaken to provide a unique national capability for testing moderate-to-large helicopter and tilt rotors in the National Full-Scale Aerodynamics Complex (NFAC). The initial LRTA testing included operating the LRTA (without blades) at speeds up to 100 knots and hover testing of the UH-60 up to full rotor speed and at 15,000 pounds of thrust. These test efforts demonstrated the structural integrity of the LRTA and verified operation of all LRTA measurement systems. With the successful culmination of these efforts, it is clear that the LRTA is ready to become the workhorse facility for NASA's large-rotor experimental programs. The first program to use the LRTA is a joint NASA/Army/Sikorsky/German effort to determine